

12.—Barley Diseases in Western Australia: Their Distribution and Pathogenic Characteristics

by T. N. Khan*, W. J. R. Boyd*
and W. A. Shipton†

Manuscript received 21 May 1968; accepted 16 July 1968

Abstract

A survey of the occurrence and distribution of the diseases of cultivated barley in Western Australia is reported.

The commercial significance of the major diseases is indicated together with information on their geographical distribution, variability of infection and their pathogenic characteristics. Differential hosts for each of these diseases have been identified, together with potential sources of host resistance.

Introduction

Approximately 5 per cent. of the area, annually sown to cereals in Western Australia, is planted to barley. The 400,000 acres involved is well distributed over the wide range of agro-ecological conditions prevailing in the cereal growing areas. Two species are planted; 2-row (*Hordeum distichum*) and 6-row (*Hordeum vulgare*). The former, which occupies 20% of the area, is traditionally utilized for malting purposes. For this reason its production is essentially concentrated in the area contained between the 14" and 20" annual isohyets (Fig. 1). In the wetter areas, in which limited cereal production occurs, and in the drier areas from which inferior malting quality grain is produced, the 6-row cultivars predominate (Fig. 1).

With the reduced significance attributed to the crop in general and the limited breeding activity and agronomic research accorded to it in the past, little summarized information is available on the distribution and pathogenic characteristics of the barley diseases occurring. The purpose of this paper is to provide much of this data, report upon those sources of host resistance that may usefully contribute to breeding programmes, and to indicate those genotypes which may aid in the identification of physiological races.

Barley diseases recorded in Western Australia

Smuts (*Ustilago* spp.) were the first diseases recorded on barley in Western Australia (Chambers, 1960a), and apparently caused some losses prior to the early 1920's (Cass Smith, 1954). Since 1954 there have been indications that loose smut is increasing in importance, particularly in the wetter areas of the State (Chambers, 1960a).

Since the identification of loose and covered smuts, 15 other diseases have been identified (Table 1). Some of these diseases occur throughout the State, and though sometimes occurring in epidemic proportions, have aroused surprisingly little interest (Chambers 1960a, Shipton 1966a).

Powdery mildew appeared to assume some importance in 1955 when it was prevalent in the wetter areas of the State. Again, in 1959 the disease was widespread (Chambers 1960a).

Scald was recorded on barley in 1926 and the first report of net blotch on barley was in 1953. It is likely, however, that net blotch had been present for some time before its identification. Net blotch and scald are economically important overseas (Anon. 1958; Yamada and Shiomi 1954). However, despite their widespread occurrence and their ability to cause considerable defoliation in W.A. (Anon. 1961; Chambers 1960b), they have received little attention. Contrary to earlier opinion (Anon. 1961) it would now appear from the work of Shipton (1966a) that net blotch is causing considerable losses in yield. The position in regard to scald is probably similar.

Stem rust appears to occur readily on barley providing the plants are not too mature at the time when inoculum is abundant in the spring. Previous records show that barley growing in the vicinity of rust outbreaks can be moderately to severely attacked (Chambers 1960a).

Barley yellow dwarf is a disease that has aroused considerable interest since its discovery in 1961 in W.A. Reports indicate that the disease is often serious in the wetter cereal growing areas. However, there appears to be some confusion between the symptoms caused by late infection by this disease and those caused by nutritional disorders. As a result there are few authentic reports.

The above mentioned diseases could be considered of major importance, based on the reports made. Little is known about the other leaf and stem diseases of barley, listed in Table 1, other than the fact that they have been recorded.

Root rots appear to be generally distributed throughout the state (Chambers, personal communications), but are apparently not a serious limiting factor to barley production.

Review of alternative hosts harbouring Recorded barley diseases in Western Australia

Records have accumulated over many years on the alternative hosts of various organisms which attack barley. The data are given in Table 2. They have been extracted from the disease lists of Chambers (1959, 1960a, 1961), McNish (1964, 1967), and the report from Khan and Boyd (1968).

Survey methods and materials

The observations and results reported in this paper have been collected since 1964. The methods used have varied and include field surveys, the growing of the 1962 International Barley Disease Nursery (IBDN) at numerous locations, together with supporting laboratory and glasshouse studies.

The initial observational survey in 1964 was followed by more systematic surveys in 1965, 1966 and 1967. Such surveys were facilitated by the fact that the commercially available cultivars are susceptible to all diseases occurring except leaf stripe (*Helminthosporium gramineum*).

* Department of Agronomy, University of Western Australia, Nedlands, W.A.

† Department of Agriculture, South Perth, W.A. (currently, Canada Department of Agriculture Research Station, Winnipeg, Canada.)

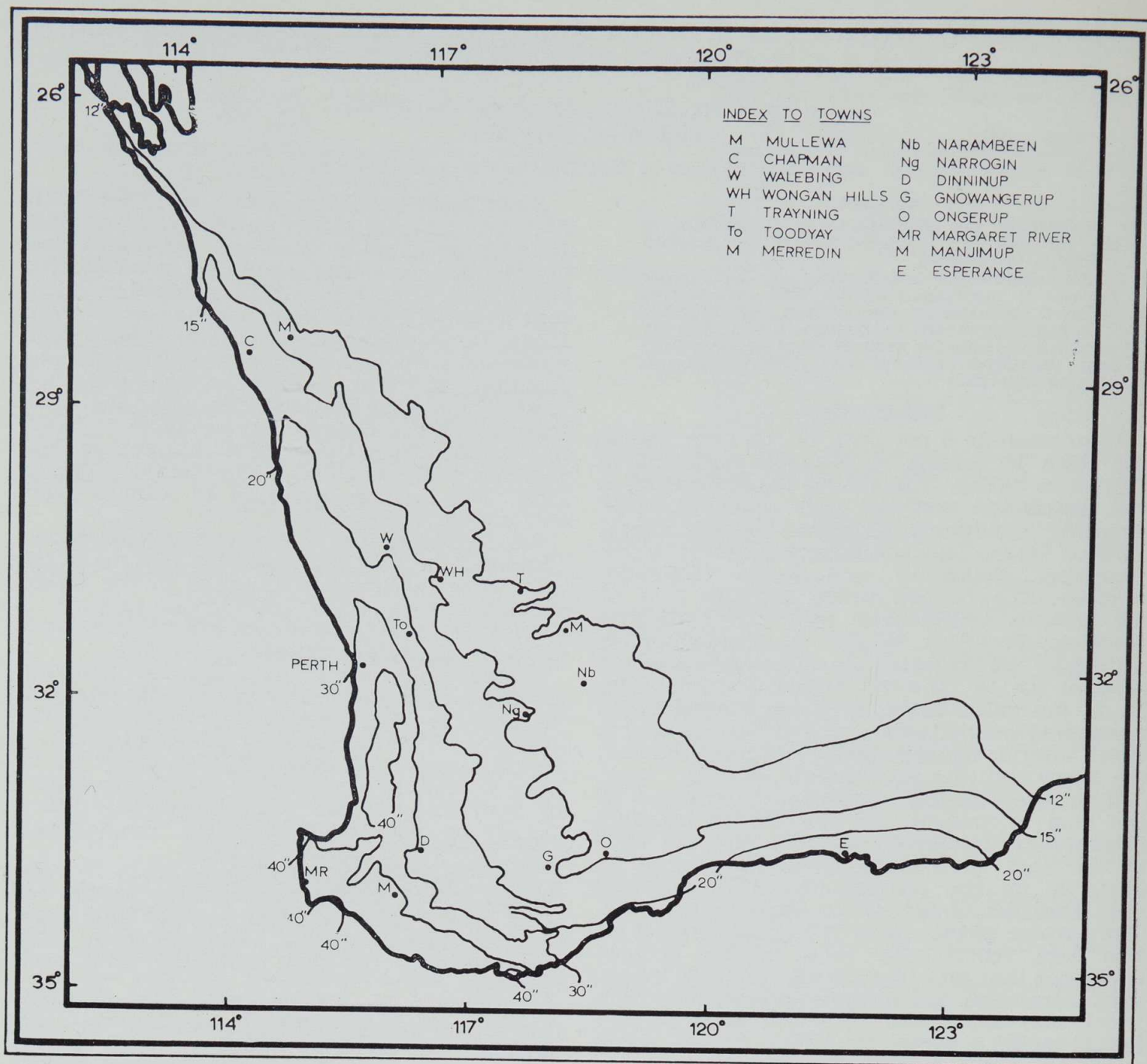


Figure 1.—The southwestern area of Western Australia, selected annual isohyets, and towns referred to in the text.

Table 1
Diseases identified on Barley in Western Australia*

Causal Organism	Disease	Year of First Record
<i>Alternaria</i> sp.	Black Mould	1959
Barley Yellow Dwarf Virus	Barley Yellow Dwarf	1961
<i>Coniothecium</i> sp.	Pink Stain	1927-28
<i>Drechslera teres</i> Drechsl.	Net Blotch	1953
<i>Drechslera verticillata</i> (O'Gara) Shoemaker	Leaf Spot	1965
<i>Erysiphe graminis</i> DC.	Powdery Mildew	1924
<i>Fusarium culmorum</i> (W.G. Sm.) Sacc.	<i>Fusarium</i> Root rot	1959
<i>Helminthosporium gramineum</i> Rabh.	Stripe	1924
<i>H. sativum</i> Pamm., King & Bakke	Foot rot	1959
<i>Mycosphaerella tulasnei</i> (Jancz.) Lindau	Black Mould	1924
<i>Ophiobolus graminis</i> Sacc.	Take-all	1927
<i>Puccinia graminis</i> Pers.	Stem Rust	1925
<i>Rhizoctonia solani</i> Kühn	Foot and Root rot	1959
<i>Rhynchosporium secalis</i> (Oud.) J. J. Davis	Scald	1926
<i>Septoria passerinii</i> Sacc. †	<i>Septoria</i> leaf blotch	1923
<i>Ustilago hordei</i> (Pers.) Lagerh.	Covered Smut	1913
<i>Ustilago nuda</i> (Jens.) Rostr.	Loose Smut	1913

* From reviews of Chambers (1960a), MacNish (1964) and unpublished data.

† Doubtful record.

Table 2

A list of additional hosts in Western Australia on which organisms causing barley diseases have been previously recorded

Organism	Hosts
Barley Yellow Dwarf Virus	<i>Avena sativa</i> L., <i>Triticum aestivum</i> L.
<i>Drechslera teres</i>	<i>Hordeum leporinum</i> Link., <i>Hordeum hystrix</i> Roth., <i>Bromus gussonii</i> Parl.
<i>Drechslera verticillata</i>	<i>A. sativa</i> , <i>Ehrharta longiflora</i> Sm., <i>H. hystrix</i> Roth., <i>H. leporinum</i> , <i>Lolium perenne</i> L., <i>L. rigidum</i> Gaud., <i>T. aestivum</i> .
<i>Fusarium culmorum</i>	<i>T. aestivum</i>
<i>Helminthosporium sativum</i>	<i>Agropyron distichum</i> Beauv., <i>Cynodon dactylon</i> (L.) Pers., <i>H. leporinum</i> , <i>Stenotaphrum secundatum</i> (Walt.) Kuntze, <i>T. aestivum</i> .
<i>Mycosphaerella tulasnei</i>	<i>Avena sativa</i> , <i>A. fatua</i> , <i>H. leporinum</i> , <i>Phalaris tuberosa</i> L., <i>Pisum sativum</i> L., <i>T. aestivum</i> .
<i>Ophiobolus graminis</i>	<i>Bromus rigidus</i> Roth., <i>B. gussonii</i> Parl., <i>H. hystrix</i> , <i>H. leporinum</i> , <i>Phalaris</i> sp., <i>Secale cereale</i> L., <i>T. aestivum</i> , <i>Vulpia bromoides</i> (L.) S.F. Gray, <i>V. myuros</i> (L.) Gmel.
<i>Puccinia graminis tritici</i>	<i>Agropyron distichum</i> , <i>A. scabrum</i> (R. Br.) Beauv., <i>Amphibromus neesii</i> Steud., <i>H. hystrix</i> H. leporinum, <i>Phalaris</i> sp., <i>S. cereale</i> , <i>T. aestivum</i> , <i>V. bromoides</i> .
<i>Rhizoctonia solani</i>	<i>Avena sativa</i> , <i>Brassica napobrassicae</i> (L.) Mill., <i>B. Oleracea</i> , <i>L. botrys</i> L., <i>B. oleracea italica</i> Plenck, <i>Lactuca sativa</i> L., <i>Lycopersicon esculentum</i> Mill., <i>Phaseolus vulgaris</i> L. <i>P. sativum</i> , <i>Solanum tuberosum</i> L., <i>Trifolium subterraneum</i> L.,
<i>Rhynchosporium secalis</i>	<i>H. leporinum</i>
* <i>Septoria passerinii</i>	<i>H. leporinum</i>

* Doubtful record

Every barley crop growing adjacent to the major and many minor roads travelled, was examined. For our purposes any disease occurring, in any one area, in each of the survey years is considered a major disease of that area. The areas covered in each of these years ranged up to the 12" annual isohyet (Fig. 1).

The IBD Nursery (provided by Dr. J. Moseman, Crop Research Division, U.S.D.A., Beltsville, Maryland) was first sown at Perth in 1965, at eleven locations in 1966 and ten in 1967 (see Fig. 2). The system of scoring used, followed that outlined in the instructions which accompanied the imported seed. At each location entries were planted in 3' rows spaced 2' apart and replicated twice. The local varieties, Prior and Beecher, were included as additional controls. In the case of these disease nurseries, a disease is considered to be of major significance

if it attacks all the susceptible controls in both replications.

In all years of the survey, samples of diseased plants were collected. These were later isolated on a range of media, and identified. Specimens not identified were sent to the Commonwealth Mycological Institute, Kew, for study.

Results and observations of surveys

The distribution of the diseases recorded

The following conclusions were reached from the results of the 4 years' surveys, rather than from the results of the IBD Nurseries. The latter data has been incorporated, but for reasons which will be discussed later, these nurseries did on occasion escape infection of a disease which was wide-spread on surrounding farms.

The diseases encountered, and their distribution, can be classified as follows:

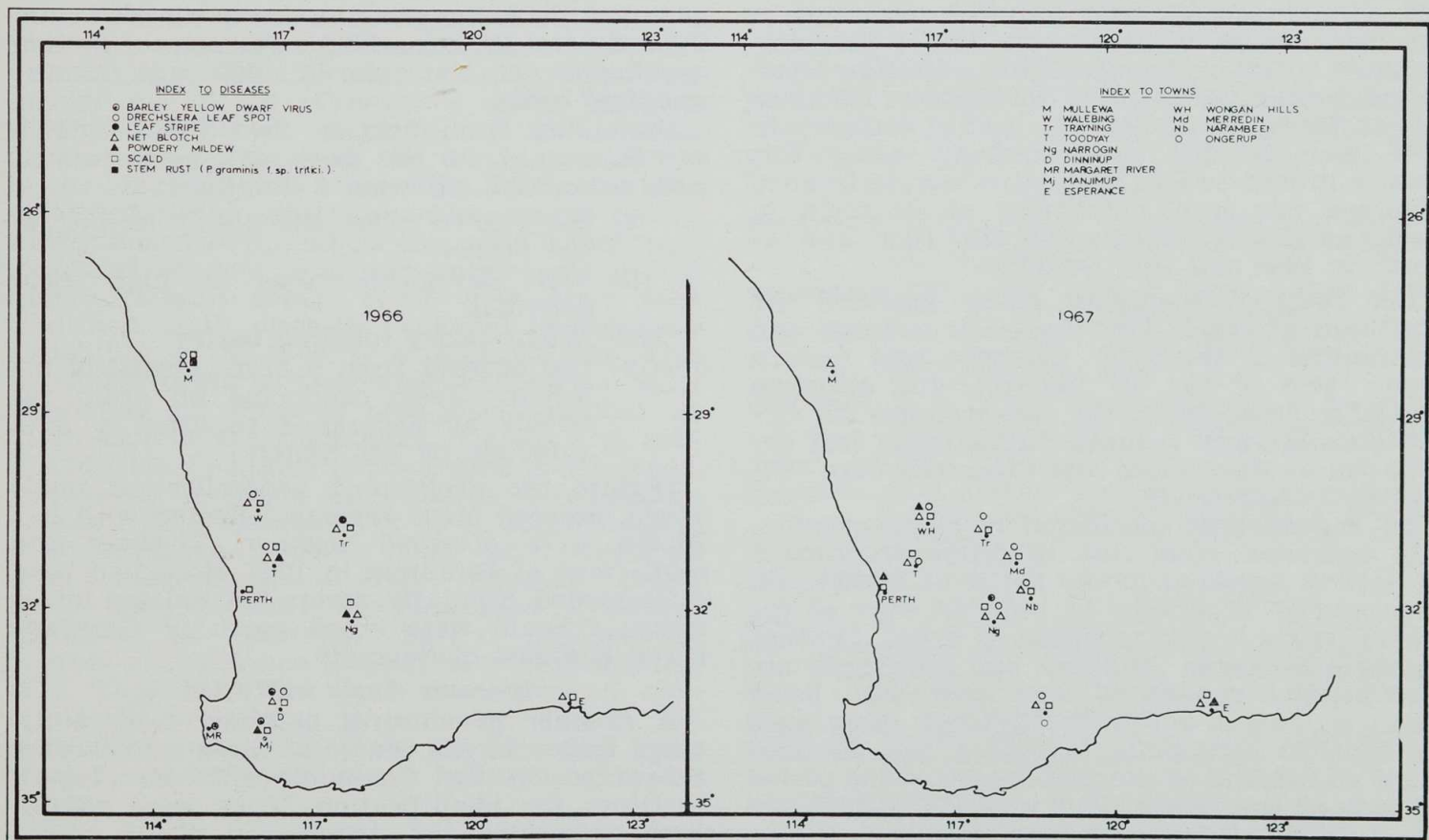


Figure 2.—The outline of the southwest of Western Australia, the locations of, and the major diseases recorded in the International Barley Disease Nurseries, planted in 1966 and 1967.

1. Regularly encountered and of widespread distribution:

Net Blotch (*Drechslera teres*)
Scald (*Rhynchosporium secalis*)
Mildew (*Erysiphe graminis*)
Leaf Spot (*Drechslera verticillata*)

2. Regularly encountered but of restricted distribution:

Rust (*Puccinia graminis* f. *tritici*)
B.Y.D. Virus
Leaf Stripe (*Helminthosporium gramineum*)

3. Irregularly encountered but of wide distribution:

Roots rots (various fungi)
Smuts (*Ustilago* spp.)

Leaf spot (*D. verticillata*) was found throughout the State, but in almost every instance, confined only to the seedling stages. It is hardly likely to be of economic significance except in those instances in which the seedlings are severely attacked and when the disease persists to a later growth stage (e.g. Walebing IBDN in 1966, see Fig. 2).

Powdery Mildew (*Erysiphe graminis*) was observed throughout the State during the period 1964-1967. Principally, however, its occurrence was most regular in the wetter western portion of the areas considered. Its appearance to the east of the 14" annual isohyet would be confined to the lower leaves of densely growing crops, unless favourable climatic conditions favoured its persistence. The disease is considered to be of economic significance only on certain occasions.

Scald (*Rhynchosporium secalis*) was distributed in much the same fashion as mildew. The disease predominates in the areas west of the 14" annual isohyet, and although recorded in the drier parts (e.g. Trayning 1967), the incidence of infection is only slight. (Average number of lesions per plant at Narembeen 1966 was 1.1, at Trayning in 1967 1.4, and at Mullewa in 1966 2.1). In the more endemic areas this disease proved serious and extremely destructive (average per cent. defoliation at Narrogin in 1966 was 71%, at Toodyay in 1967 58%, and, at Perth in 1966 and 1967, 90-95%).

Net Blotch (*Drechslera teres*) provided the antithesis of scald. This disease is endemic and destructive in the drier northern and eastern areas (west of the 14" isohyet), and although regularly observed in the wetter areas its significance is much reduced. Estimates of leaf defoliation at Narembeen and Chapman were 78% and 95% respectively.

Of the diseases considered to be geographically restricted, stem rust (*Puccinia graminis* f. *tritici*) occurred in the IBDN at Mullewa in 1966 and at Esperance in 1967. In each of the survey years it was recorded in areas adjacent to these nurseries. Mullewa and Esperance are traditionally considered the most rust liable districts. This is due to the frequent occurrence of climatic conditions favouring the development and spread of the rust fungus in the period after head emergence. This is earlier at Mullewa (September), than Esperance (October) (Ship-ton 1966). In the event of unseasonally late rains occurring at these times the possibility of

rust attack exists. Such was the case at Merredin in 1964. At Perth rust has been observed from 1965-67 in late season irrigated crops.

Barley yellow dwarf virus was observed in the higher rainfall areas in the S.W. corner of the State. The I.B.D. Nurseries located in this area in 1966 were severely attacked (Margaret River) or seriously infected (Manjimup and Dinninup). One of us (W.S.) has observed this disease at Beverley but symptom expression is only poorly developed.

Helminthosporium gramineum, the casual agent of leaf stripe, failed to reveal itself on any of the commercial varieties grown or upon the controls in the IBDN. Its presence, however, can be determined from its attack on the variety San Carlos (C.I. 11533), and this has occurred only at Trayning in 1966 and 1967 and at Narembeen in 1967. In 1965 it was recorded, at Perth, on the variety Odessa (C.I. 934).

The remaining diseases, root rots and smuts (*Ustilago* spp.) have been recorded on a very few occasions and from widely separated areas.

The severity of disease incidence, and its variability

The most noteworthy aspect of the surveys conducted relates to the above variability. Net Blotch, which proved endemic and serious in the drier areas, (corresponding to an area east of a line linking Mullewa, Trayning, Gnowangerup and Esperance) showed little incidence in the 1966 Trayning and Esperance nurseries. In surrounding areas, however, very severely affected crops could be observed. Similar variability was experienced with Scald. This disease which proved endemic and serious in the higher rainfall areas (resulting in complete defoliation in some instances e.g. Narrogin, Toodyay and Perth in 1966), was only of limited significance at Narrogin in 1967 and in surrounding areas.

Variability from field to field was observed, and this could, for the most part, be associated with any of the following 4 situations:

- (i) Early sown crops (inevitably leading to (ii) below)
- (ii) Well developed crops of high yield potential
- (iii) When barley followed barley
- (iv) Use of seed from a crop previously infected. (Tests conducted on grain receivals at Esperance recorded a 35% infection of Net Blotch.)

Despite the geographic generalization made above, isolated crops severely affected with Net Blotch were observed west of Toodyay and south-west of Dinninup in 1966. Both had been early seeded. Similarly, severe but isolated infections of Scald were noted north of Gnowangerup and east of Narrogin.

Diseases newly identified

A number of cultures obtained from cultivated barley in the course of these studies were forwarded to the Commonwealth Mycological Institute for identification. They were as follows:

CMI 128829 *Cladosporium herbarum* (Pers.)
Link ex Fr.

- 128830 *Pyrenophora semeniperda*
(Brittlenneck + Adam)
Shoemaker.
128832 *Colletotrichum graminicola*
(Ces.) Wilson
128834 *Mocrophoma* sp.
128835 *Alternaria* stage of *Pleospora*
infectoria Frickel.

Identification of previously unreported wild hosts

The following hosts for the fungus *D. verticillata* were found:

- Briza maxima* L., *B. minor*, *Bromus gussonii*, *B. rubens* L. *Phalaris minor* Retz., *Polypogon monspeliensis* (L) Des. f.

Pathogenic variability encountered

Studies of "Field" pathogenic variability were limited to those nurseries in which the disease in question was present in epidemic proportions, and where the control varieties in each replicate were severely attacked. The results obtained are summarized below (see Table 3).

It may be noted that, for four diseases, evidence of pathogenic variability was obtained. For each, suitable differential cultivars were identified. In Table 4 cultivars resistant at all locations to one or more of the diseases studied is presented. It may be noted that 2 cultivars are recorded as resistant to BYD virus. No complete resistance was recorded however. At the Margaret River location all cultivars were affected. The two indicated as resistant revealed some degree of tolerance. This tolerance was more marked at Manjimup and Dinninup. A number of cultivars were recorded as resistant to *D. verticillata*.

Conclusions

As a result of the above reported surveys and studies, a number of conclusions may be drawn. Seven major barley diseases occur in W.A. They include net blotch (*Drechslera teres*) which is widely distributed, endemic in the shorter growing season areas in the north, and serious in the lower rainfall areas. Two field races were identified. Scald (*Rhynchosporium secalis*) proved widely distributed, and its economic significance increased to near epidemic proportions in the higher rainfall areas. Three field races were identified. Both diseases exhibited considerable variability in the severity of their attacks. This variability could be associated with earlier dates of seeding and crops of high yield potential. As these aspects are themselves related, it is presumed that a suitable microclimate is developed, facilitating infection and disease development. As grain yield reductions of up to approximately 20% (Shipton 1966a) have been reported from moderately severely affected crops, these diseases must be considered a serious limitation to improved barley productivity. Sources of resistance to both have been located. (See Table 4). The need for improved crop sanitation procedures is indicated due to the seed-borne nature of these diseases and their greater incidence in crops following previous barley.

Two widely distributed, but apparently less significant, diseases to be encountered were powdery mildew (*Erysiphe graminis*) and leaf

Table 3

Indicating the number of field races identified for each of the following diseases, and suitable differential varieties for their identification (UR = Universal Resistant; US = Universal Susceptible)

Disease	Number of field races identified	Differentials
Net Blotch (<i>Drechslera teres</i>)	2	Marocaine 079 (CI8334), Nepal (CI595) UR = Abyssinia (CI9588) US = Prior
Scald (<i>Rhynchosporium secalis</i>)	3	Hispont (CI8828), Trebi (CI936), (CI1234) UR = Marocaine 079 (CI8334) US = Prior
Powdery Mildew (<i>Erysiphe graminis</i>)	2	Gopal (CI1091) Valentine (CI7242), Goldfoil (CI 928)* UR = Hispont (CI8828) US = Prior
Stem Rust (<i>Puccinia graminis</i>)	2	Feeber (CI7260) Valentine (CI7242) UR = Husky (CI9537) US = Prior

* Goldfoil is a differential for races 3 and 18 of *E. graminis* (Luig et al 1958).

spot (*D. verticillata*). Both diseases were more prevalent in the wetter regions of the State, and both were particularly prevalent during the seedling stages of growth. Considerable variability of seedling incidence was observed, but no plausible reason could be developed. Two field races of powdery mildew were encountered and sources of resistance to both diseases were identified.

The remaining three diseases considered to present a serious potential problem were rust (*P. graminis* f. spp. tritici), BYD virus and *Helminthosporium gramineum*. Each revealed distinct geographic isolation. Two field races of rust were encountered and sources of resistance or tolerance (to BYD virus) were observed.

References

- Anonymous (1958).—Report of the Minister of Agriculture for Canada for the year ended March 31st, 1958, pp. 144.
Anonymous (1961).—Net blotch of barley. *J. Dept. Agric. West. Aust.* 2 (4th series): 555-556.
Cass Smith, W. P. (1954).—Cereal Smut Diseases and their Controls. *J. Dept. Agric. West Aust.* 3 (3rd series): 329-338.
Chambers, S. C. (1959).—A revised list of vegetable diseases recorded in Western Australia. *J. Dept. Agric. West Aust.* 8 (3rd Series): 427-432.
Chambers, S. C. (1960a).—Diseases recorded on Cereals, Grasses and Pasture Legumes in Western Australia. *J. Dept. Agric. West. Aust.* 1 (4th Series): 1129.
Chambers, S. C. (1960b).—Scald of Barley. *J. Dept. Agric. West. Aust.* 1 (4th Series): 927-934.
Chambers, S. C. (1961).—Plant Diseases in Western Australia. Supplementary list of diseases recorded on vegetables, cereals, grasses and pasture legumes. *J. Dept. Agric. West. Aust.* 2 (4th Series): 841-842.
Khan, T. N. and Boyd, W. J. R. (1968).—Gramineae species harbouring *Drechslera teres* in Western Australia. *Aust. J. Sci.* 1 30: 373.
Luig, N. H., McWhirter, K. S. and Baker, E. P. (1958).—Mode of inheritance of resistance to powdery mildew in barley and evidence of an allelic series conditioning reaction. *Pro. Linn. Soc. N.S.W.* 83: 340-362.

Table 4

Varieties resistant to specific diseases at all W.A. Locations tested (*). Varieties reported as resistant to these diseases in other countries are noted (†). This information has been obtained from details supplied with the 1962 I.B.D.N. and Moseman (1964)

Varieties resistant at all locations to :

Variety	CI No.	Origin	BYDV ‡	Drech- slera leaf spot	Net Blotch	Powdery Mildew	Scald	Stem rust
Algerian	1179	Algeria	.....	.....	*	*†	.....	.....
Anoidium	7269	Argentina	*†	.....	.....	.....	.....	.....
Anoidium x BC 2562 (Rabat) 04805-9-5-20	11538	Canada	.....	.....	.....	*†	.....	.....
Anoidium x BC 2562 (Rabat) 04805-10-13-1-1	11539	Canada	.....	.....	.....	*†	.....	.....
Belli Barley	6182	Hybrid	.....	*	.....	.....	.....	.....
Black Russian	2202	Tiflia	.....	.....	*	.....	.....	.....
Br. Sel. 3962-4	11542	Canada	.....	.....	*	.....	.....	.....
Br. 5180-30	.....	Canada	.....	.....	*	.....	.....	.....
Br. 5746-2g M.R. JV	.....	Canada	.....	.....	*	.....	.....	.....
Cebada Cape	6193	North Africa	.....	.....	†	.....	.....	.....
Comfort	4578	Hybrid	.....	.....	*	.....	.....	.....
Decortiatum	2230	Hybrid	.....	.....	.....	.....	*	.....
Div. 6472-58-12313	.....	Argentina	.....	.....	.....	.....	*	.....
Dorsett	4821	Manchuria	.....	.....	.....	*†	.....	.....
Engledow India	7555	Argentina	.....	.....	.....	*†	.....	.....
Goldfoil	928	Pl. Sel.	.....	.....	*	.....	.....	*†
Hispont	8828	Germany	.....	.....	*	.....	.....	*†
Husky	9537	Canada	.....	.....	*	.....	.....	*†
J 20	.....	Japan	.....	.....	.....	*†	.....	.....
Kinai No. 5	.....	Japan	.....	*	*	.....	.....	.....
Long Glumes	6168	Hybrid	.....	.....	.....	*†	.....	.....
Manchuria	2330	China	.....	.....	*	.....	.....	.....
Marocaine 079	8334	France	.....	.....	.....	*†	.....	.....
Mainwali	3400	India	.....	.....	.....	*†	.....	.....
Modia	2483	North Africa	.....	.....	.....	*	.....	.....
Monte-Cristo	1017	India	.....	.....	.....	*	.....	.....
Moore	7251	Wisconsin	.....	.....	.....	.....	.....	*†
Multan	3401	India	.....	.....	.....	*	.....	.....
O.A.C. 21	1470	Canada	.....	.....	*†	.....	.....	.....
Oderbrucker	940	Pl. Sel.	.....	.....	*	.....	.....	.....
Psaknon	6305	Australia	.....	.....	.....	.....	.....	.....
Quinn	1024	Australia	.....	.....	.....	.....	.....	.....
Rabat	4979	Morocco	.....	.....	.....	*	*†	.....
Russ. No. 68	.....	Japan	.....	*	.....	.....	.....	.....
Russ. No. 74	.....	Australia	.....	.....	.....	.....	*	.....
Speciale	7536	Hybrid	.....	.....	*	.....	.....	.....
Spiti	.....	Argentina	.....	.....	.....	*	.....	.....
Stephan	8051	Germany	.....	.....	*	*†	.....	.....
Sudan	6489	Portugal	.....	.....	*	*†	.....	.....
Tregal	6359	Hybrid	.....	*	.....	.....	.....	.....
Weihenstephen	.....	Japan	.....	*	*	.....	.....	.....
	1243	Abyssinia	.....	.....	*†	.....	.....	.....
	2376	Abyssinia	.....	.....	.....	.....	*	.....
	2549	Italy	.....	.....	*	.....	.....	.....
	3208	Abyssinia	.....	.....	.....	.....	*†	.....
	-1	.....	.....	.....	.....	.....	.....	.....
	3906	.....	.....	.....	.....	.....	.....	.....
	1	Abyssinia	.....	.....	.....	.....	*†	.....
	3926	Abyssinia	.....	.....	*	.....	*	.....
	3	.....	.....	.....	.....	.....	.....	.....
	4220	.....	.....	.....	.....	.....	.....	.....
	1	Abyssinia	.....	.....	*	.....	.....	.....
	4226	China	.....	.....	*†	.....	.....	.....
	4487	Manchuria	.....	.....	*	.....	.....	.....
	4493	Manchuria	.....	.....	*	.....	.....	.....
	4578	Hybrid	.....	.....	*	.....	.....	.....
	4795	Manchuria	.....	.....	*†	.....	.....	.....
	4929	Manchuria	.....	.....	*†	.....	.....	.....
	4935	Manchuria	.....	.....	*	.....	.....	.....
	5644	Atrada Kuban	.....	.....	.....	.....	*†	.....
	7117	.....	.....	.....	.....	.....	.....	.....
	77	.....	.....	.....	*	*†	.....	*†
	7251	Wisconsin	.....	.....	.....	.....	.....	*†
	7619	India	.....	*	.....	*†	.....	.....
	7728	India	.....	.....	.....	*†	.....	.....
	8111	Pl. Sel.	.....	.....	*	*†	.....	.....
	8158	Turkey	.....	.....	*	.....	*†	.....
	8159	Argentina	.....	.....	.....	.....	*†	.....
	8251	Turkey	.....	.....	.....	*	*	.....
	9588	Abyssinia	*†	*	*	.....	.....	.....

‡ Varieties tolerant to BYDV

MacNish, G. M. (1964).—Supplementary list of diseases recorded on various hosts in Western Australia. *J. Dept. Agric. West. Aust.* 5 (4th Series): 991-995.

MacNish, G. M. (1967).—Supplementary List of Diseases Recorded on Various Hosts in Western Australia. *W.A. Dept. Agric. Bulletin* No. 3481.

Moseman, J. G. (1964).—Present status of plant pathological research on barley in the United States. *Barley Genetics I—Proceedings of the 1st International Barley Genetics Symposium. Wageningen 26-31 Aug. 1963. Agric. Pub. and Documentation, Wageningen 1964: pp. 250-258.*

Shipton, W. A. (1966a).—Effect of net blotch infection on grain yield and quality. *Aust. J. Exp. Agric. Anim. Husb.* 6: 437-440.

Shipton, W. A. (1966b).—Summer and autumn rainfall in relation to epidemics of wheat stem rust in Western Australia. *J. Dept. Agric. West. Aust.* 7 (4th Series): 165-169.

Shipton, W. A. and Chambers, S. C. (1966).—The internal microflora of wheat grains in Western Australia. *Aust. J. Exp. Agric. Anim. Husb.* 6: 432-436.

Yamada, W. and Shiomi, T. (1954).—Studies on the *Rhynchosporium* scald of barley. 1. General consideration of the disease and the fungus and on the varietal resistance to the disease. *Spec. Bull. Okayama Pref. agric. Expt. Sta.*, 50: 212-232. (*Rev. app. Mycol.* 35: 601).